Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

THE EXPLORATION OF THE SEA.

BY CHARLES MINOR BLACKFORD, JR., M. D.

WHO is there in whom the sight and sound, or even the very mention of the sea does not arouse an interest, even enthusiasm? The sea has ever been a theme for artist, poet and orator. It furnished a highway for Hellenic traffic, and about it clustered many tales and traditions, many beautiful mythological fancies, many half historic stories. It was a second home for the Hellenic people, and it is easy to understand the joy with which the ten thousand under Xenophon hailed it with shouts as they saw from the hilltops the glitter that marked the end of their long and weary retreat.

The dancing ripples, the steady heaving of the tides and the resistless power of the waves when hurled by storms on the shore, excited the imaginations of early men, and thus peopled the waste of waters with deities. In the warm, mild seas, the Ægean and Mediterranean, Neptune held his court, attended by mermaids and dolphins, to whom even Orpheus deigned to play. Among its terrors were Scylla and Charybdis and the sirens. In the forbidding waters of the north the Lorelei held sway; and Undine lived in a palace as rich in barbaric splendor as the caverns of Capri in sensuous tints.

These were but fancies, for as to the real life of the sea the ancients were ignorant. Its simplest problems were inexplicable, for even Aristotle failed to understand its saltness. He argued that, as the water was continually evaporating, the sea would ultimately dry up, and as the upper layers are exposed to the sun, they must be warmer and more salt than those beneath them. He named 180 species of marine animals inhabitating the Ægean Sea, a truly wonderful feat for one who did not possess instruments or modern chemical, physical and biological knowledge.

Pliny, in his gossipy Natural History, gives a list of 176 species, which, though four less than those given by Aristotle for the Ægean alone, he asserted to comprise all to be found in the sea, and complacently remarks:

> "Surely, then, everyone must allow that it is quite impossible to include every species of terrestrial animal in one general view for the information of mankind, and yet, by Hercules, in the sea and in the ocean, vast as they are, there exists nothing that is unknown to us, and, a truly marvellous fact, it is with those things that nature has concealed in the deep that we are best acquainted."

He states the depth of the sea to be 1,500 fathoms in some places, and in others to be immeasurable. In regard to the saltiness, he repeats Aristotle's view that the surface strata are more saline than the deeper ones, because "what is sweet and mild is evaporated from it, which the force of fire easily accomplishes, while all the more acrid and thick matter is left behind, on which account the water of the sea is less salt at some depth than at the surface."

During the Middle Ages, little was done save to repeat the teachings of Aristotle, and beyond question the fabulous dangers of the ocean delayed the discovery of America. The voyages of Columbus and his followers excited anew the old interest in marine life, and in 1558 Gessner published a "*Historia Animalium,*" the fourth book of which is on "Fishes and Sea Animals." The slender store of knowledge of pelagic life received its next addition from "A Treatise on Aquatic Life," by John Jonston, in 1649, and, about 1650, Hooke invented a sounding rod with a detachable weight, an idea that slumbered two hundred years, till Passed Midshipman J. M. Brooke, a young Virginian in the United States Navy, † invented in 1854, a rod embodying it, that is so perfect that Sigsbee says of it: "In fact there is no sounding rod . . . that is not a modification of Brooke's rod in one respect or another."

The first attempt to explore the sea in the scientific sense was that made by Ellis off the northeastern coast of Africa. He succeeded, in 1749, in sounding, at a depth of 891 fathoms, and made observations of the temperature of the deeper strata of water by drawing up specimens in a valved box, so arranged as to close on striking bottom, and taking the temperature on deck after the box had been drawn up. This process was more ingenious than adapted to precise results. The next year, 1750, two Italian naturalists, Marsili and Donati, used the common oyster dredge for collecting specimens, and as early as 1779, Otho F. Müller, a Dane, invented the "Zoologists' Dredge" by fastening a net to an iron frame, and the modern era was definitely begun.

---

† Now Prof. J. M. Brooke of the Virginia Military Institute.

The progress of thalassography has been so rapid and so great during this century, that it can be sketched only in bare outline. In 1805 Pêron went around the world and took temperatures at many points. He conceived the remarkable idea that at the bottom of the sea lay a bed of ice, though he neglected to mention the manner in which it was fastened down. Preposterous as is this idea, it survived for thirteen years, when Sir John Ross upset it. This latter explorer invented an apparatus, called the "Deep Sea Clamm," a gigantic pair of tongs by which he secured specimens of the bottom and several worms from more than 1,000 fathoms. Of course, had Péron's ice sheet lain over the bottom, the "Clamm" would not have brought up earth, but it is strange, in view of what was to follow, that the presence of the annelids attracted so scant attention.

When marine life began to command notice, the question of the depth to which life could extend divided scientific thought into warring camps. About 1840, it was generally believed that the bathymetrical limit was about 300 fathoms, and some strange ideas were current as to the physical condition of water when under a pressure such as a depth of two miles would produce. It was thought that skeletons of drowned men, or even heavy cannon and the "wedges of gold" that popular imagination places in the sea, floated at certain levels, beneath which is water so compressed as to be impenetrable. In fact, water is almost incompressible, and the weight of a cubic inch of it at the depth of a mile is very little more than at the surface; but it was assumed that no living being could survive a pressure which at 1,000 fathoms is about a ton to the square inch. We ourselves live under a pressure of about fifteen pounds per inch, and are unaware of it. Indeed, we sometimes waken on a morning when the barometer has risen, say, half an inch during the night, and consequently find ourselves sustaining an increased pressure of several tons not only without suffering, but with a positive feeling of buoyancy and good spirits. On the other hand, if the tremendous pressure under which we live be relieved as by a surgical "cup," severe injury may follow. Aëronauts suffer from this cause, and marine animals dredged from great depth often reach the surface in a most lamentable condition, with eyes protruding and viscera distended.

The notion that life could not exist below 300 fathoms soon received heavy blows. Ross had brought up worms in mud from 1,000 fathoms, and entangled on the line at 800 fathoms was a beautiful *Caput Medusæ.* Off the coast of Portugal there is a fishery of sharks carried on below 400 fathoms, and it is thus demonstrated that animals so high in the scale can survive a pressure of 1,120 pounds to the inch. But these facts, and others equally forcible, seem to have been overlooked in favor of a plausible hypothesis, especially when the latter bore the stamp of a great name. In 1843 Edward Forbes, then professor of botany in King's College, London, read a paper on the *mollusca* and *radiata* of the Ægean Sea and their distribution, considered as bearing on geology. For a botanist to discuss a zoological topic from a geological standpoint is remarkable, but this paper was the beginning of a series of works on marine life that were in the very front of the thought of the time. Space compels the omission of his ideas of distribution from specific centres, his "Law of Representation" and much of interest and ingenuity that sprang from his brain; but his "Bathymetrical Zones" require mention because of the influence they exerted on science. He distinguished around all seaboards four well marked zones of depth, each characterized by a distinct group of organisms. These zones he called the Littoral, Laminarian, Coralline and the Zone of Deep Sea Corals. Of these, the Littoral extends between high and low water marks, and is periodically exposed to air, sun, and extremes of temperature. Animal *species* are rare, though *individuals* are many, and of them, many are vegetable feeders. From low water mark to about fifteen fathoms extends the Laminarian Zone, and it constitutes the chief home of the "tangles." It is always under water, except that at lowest ebb of the spring tides glimpses of its upper margin can be seen. The Coralline Zone extends to about fifty fathoms and vegetation is represented by millepores, zoophytes and bryozoa. Most sea fish—cod, haddock, etc.—inhabit this zone, though sometimes they go deeper.

Beneath this lies the zone of deep sea corals, in which life grows less and less, till it reaches zero. Erroneous as is this system, it is a great advance on what had gone before, but it was destined to be short lived. Ross had brought up living organisms from depths far below Forbes' zero, and with improved dredging and sounding implements, it was shown that life was abundant even in abysmal regions. Sir James Clark Ross, R. N., dredging in 270 fathoms, lat. 73° 03′ S., lon. 176° 06′ E., reports "*Corallines, Flustræ* and a variety of invertebrate animals," and further in the same paragraph says: "Although contrary to the general belief of naturalists, I have no doubt that, from however great a depth we may be enabled to bring up the mud and stones of the bed of the ocean, we shall find them teeming with animal life,"—a prediction that has been amply fulfilled. In regard to the same cruise, J. D. Hooker says that in lat. 33° 32′ S., lon. 167° 40′ E., living specimens of *Hornera frondosa,* four other corals, an *annelid,* a *dictropia,* etc., were brought from 400 fathoms, besides which many infusoria and other evidences of life at 1,000 fathoms; and an unsigned paper claims that during Sir John Franklin's ill-fated expedition, the dredge was used at 300 fathoms; a depth evidently believed by the writer to have been unprecedented. In this he was in error, as the cases cited above will show.

The time was now ripe for true exploration, for scientists all over the world became interested in the strange new universe of water. In 1851, Michael Sars, a Norwegian, published a list of 13 species of living organisms from 300 fathoms. His son, G. O. Sars, aided the father in this work, and in 1864 he himself published a list of 92 species whose habitat lay between 200 and 300 fathoms beneath the surface. The collections made by these two have been of more service to science, though somewhat indirectly, than have many of ten times their size. For among those who saw them was Sir C. Wyville Thomson, and, gazing on those strange forms of life, he found food for much reflection. A mind like his needed no second hint, and at once he interested his friend, Dr. Carpenter, then a vice-president of the Royal Society, and enlisted his influence with the Admiralty to such purpose that the gunboat "Lightning" was put at the service of Thomson and his ally. The craft was ill adapted to the work, but it was a beginning, and a cruise was made off the northern shores of Scotland in 1868. The main object of this cruise was to determine, if possible, the effect of pressure on animal life at great depths, and the results of the diminution of light, besides a number of minor problems. The cruise was successful, despite the unsuitableness of the vessel. It was shown that life was abundant at 650 fathoms, and that consequently Forbes' zero did not exist—at least, anywhere near the depth suggested by him. The prevalent idea that beneath a certain level the temperature was uniform was found to be an error, and a distinct oceanic circulation was discovered, in which currents of water at 2° C. were found quite near currents of a high temperature. Finally it was seen that a large proportion of deep sea forms were of new genera and species, thus opening a new world to the zoologist and botanist. Many of these new found organisms are identical with those of tertiary fossils or are sufficiently allied with them to explain some riddles and help clear up some of the problems of geology.

In the mean time, a battle was being waged over the organisms dredged from great depths. Among them were many *Rhizopods*, the most abundant being *Globigerina* and *Orbulina universa*. The first is a complex shell, like several spheres fastened together but communicating by a minute passage, to which the class owes the name *Foraminifera*. The second is a tiny perforated sphere, through the holes in which the protoplasm can be protruded and withdrawn. In parts of the ocean, these are so abundant that their shells or external skeletons make a peculiar sort of mud, called an "ooze," that covers vast tracts. As this ooze is found in abysmal depths, far below the assumed limit of life, it was suggested that the organisms had lived on the surface but had sunk to the bottom after death. Specimens were forwarded to Professors Ehrenberg of Berlin and Bailey of West Point, but these two high authorities disagreed; the former holding that, as the dead *Globigerina* was much heavier than its bulk of water and there was no reason to think that life altered this, the probability was that they had lived where found; but Bailey held that they more probably lived at or near the surface and sank after death. With a view to deciding the point, specimens were submitted to Prof. Huxley from those collected by Capt. Dayman of the "Cyclops" in 1857, who inclined to the view that they lived where found, though admitting it to be far from proven.

The question was soon settled in a manner simple and conclusive. A telegraphic cable was laid in 1857 through the Mediterranean between Sardinia and Bona, off the coast of Africa. It failed completely in 1860, and the task of picking it up and remedying its defects was intrusted to Mr. Fleeming Jenkin, C. E., afterward Professor of Engineering in the University of Edinburgh. The cable had broken in seventy fathoms, but the sea end traversed a wide submerged valley of nearly 2,000 fathoms. When this was recovered, it was found to be covered with marine growths, many of which must have fastened on the cable while young and grown to maturity on it. Now at 2,000 fathoms the pressure approximates a ton and a half per square inch, yet Professor Allman, F. R. S., gives a list of fifteen forms, including the *ova* of a cephalopod, that had affixed themselves to the cable. The *ova* show, not merely that comparatively high organisms can survive this enormous pressure, but that they can fulfill the highest function of organisms, that of reproduction. M. Alphonse Milne-Edwards also prepared a paper and read it before the Academy of Sciences on July 15, 1861, in which he described the organisms found on the cable below 1,000 fathoms. One of them was a hitherto undescribed coral, to which he gave the descriptive name of *Thalassio trochus telegraphicus.*

As soon as it was settled indisputably that the organisms dredged from on or near the bottom of the sea lived where found, Professor Thomson again brought pressure to bear on the Admiralty for a vessel with which to explore this new realm. Private means avail but little in such an undertaking, and Governmental aid is essential, and it is a matter for congratulation that H. M. Surveying Ship "Porcupine" was commissioned on March 18, 1869, and ordered to be equipped for deep sea dredging. The "Porcupine," though small, was admirably adapted to its purpose, and her officers—Capt. Calver, Staff Commander Inskip, Lieutenant Browning and Mr. Davidson—aided the scientific staff with an intelligence and zeal that went far toward making the cruise an unqualified success.

During these years a discussion was going on among biologists that was of the greatest interest, scientific and otherwise, to scientists as well as to many without that category. The researches of Pasteur, Lister and others had shown putrefaction, suppuration and fermentation to be due to the action of living organisms, and much interest attached to the origin of these beings. A large school, led by Bastian, held that life could be spontaneously generated, and this they asserted to be proven by experiment. It was claimed that it was a logical necessity of the theory of evolution, and that the dogma "*omne vivum ex vivo*" was fatal to evolution as a complete system. Tyndall and other careful experimenters destroyed their claim to experimental demonstration, and the doctrine of "abiogenesis" was falling to pieces, when unexpected aid came to it.

In dredging at the bottom of the Bay of Biscay, Thomson and Carpenter found a soft, gelatinous matter that appeared to be alive. It was like protoplasm, but was capable of indefinite increase in size, was not nucleated, nor did it reproduce itself; but it was thought to eat, move, and be sensitive. Huxley had seen it in 1868, and, in 1872, Bessels obtained it on the unfortunate "Polaris;" but, on the other hand, the "Challenger" failed to secure it. Says Thomson:

> "If the mud (containing it) be shaken with weak spirit of wine, fine flakes separate like coagulated mucus, and if a little of the mud in which this viscid condition is most marked be placed in a drop of sea water under the microscope, we can usually see after a time, an irregular network of matter resembling white of egg, distinguishable by its maintaining its outline and not mixing with the water. This network may be seen gradually altering in form, and entangled granules and foreign bodies change their relative positions. The gelatinous matter is, therefore, capable of a certain amount of movement, and there can be no doubt that it manifests the phenomena of a very simple form of life."

To this supposed being Huxley gave the name of "*Bathybius haeckelii;*" and it was greeted with a flourish of trumpets by the materialistic faction. It was claimed to be inorganic matter in the very act of becoming organized, and to demonstrate that life was but a question of molecular arrangement. Huxley wrote a paper in support of these views, but the rejoicing was short lived. Biogenesis did not yield without a struggle, and a few experiments destroyed the *Bathybius.* It was noticed that it was seen only in alcoholic preparations, and it was next observed that when alcohol was poured into sea water a precipitate of calcium sulphate is thrown down that presents every appearance of the so-called *Bathybius.* The calcareous plates and other features that had been so carefully studied, and that had been so bewildering from their endless variations, proved to be accidental inclosures, and the mystery stood explained. As soon as Professor Huxley became convinced of his error, he admitted that he had been led astray and, in his discussion with Bastian, showed himself one of the staunchest advocates of biogenesis and did as much as did anyone to establish the truth that all life springs from life.

From this time, the seas have been thoroughly explored, and so many expeditions have gone forth that it is impossible to sketch each one, however lightly. There is one that is as yet unique in the annals of science and some mention must be made of it, not only because of the perfect manner in which those actually engaged in the cruise performed their part, but also on account of the thorough and scientific way in which the reports and collections have been utilized. This expedition is that of the famous "Challenger."

The work of the "Lightning" and the "Porcupine" had thoroughly aroused the leading scientific men of England to the importance of marine life. The objections of the Admiralty, if any had existed, had been overcome, and, in 1872, H. M. S. "Challenger," a corvette of some 2,300 tons displacement, was put in commission for a three years' cruise. She sailed on December 21, 1872, and returned on May 26, 1876. It is safe to say that no expedition that has ever sailed has added so materially to the world's stock of knowledge, both by destroying errors and accumulating truths. The expedition was under the scientific supervision of Sir C. Wyville Thomson, who also undertook the publication of the scientific reports after his return. The task proved too much for his strength, and failing health forced his retirement some months before his death, which occurred in March, 1882, an event that was lamented by the whole scientific world.

The University of Edinburgh volunteered to care for the specimens sent home from time to time, and as each consignment reached its destination the cases were unpacked and the contents examined and compared with the accompanying catalogue, after which the bottles and other containers were replaced in the original boxes. It is convincing evidence of the great skill of the naturalists on board that of the thousands of bottles but three were broken, not a single specimen was lost, and very few suffered from leakage or from evaporation of the spirit in which they were preserved.

On the return of the vessel a question arose as to the disposition of the vast store of material, and whether the preparation of the reports should be confined to British naturalists. A liberal policy prevailed, and eminent men from all over the world cooperated in producing a set of reports that is a veritable encyclopedia of the sea and its coasts. The official reports fill forty-eight large volumes, of which zoology has forty; botany, two; physics and chemistry, two; the "narrative," three; and one is devoted to a general summary of results. This set seems to cover the ground quite thoroughly, but besides the reports the books, monographs and articles based on this celebrated expedition are fairly innumerable.

This cruise added to science fourteen new species of birds, 250 new species of fishes, thirty-two varieties of cuttlefish, forty-nine new species in one order of the holothurians or sea cucumbers, and thousands of new Radiolarians. Eight out of fifteen known insects that walk on water were found by the " Challenger," and our knowledge of relationships between classes of organisms made much more complete. Indeed, the history of thalassography may be divided into two eras—before the " Challenger " and after it.

Were any description of later expeditions attempted this paper would be far too long, but the excellent work of American investigators cannot be overlooked. The Navy Department, the Coast and Geodetic Survey, the Fish Commission and individuals working in behalf of the Smithsonian Institution, have done admirable work that is equal to any done abroad, and private funds have supplied means by which much has been accomplished. Harvard, Yale, Columbia, Johns Hopkins and other colleges have working laboratories on our coast, or in the Bahama Islands, that rival the famous zoological station at Naples, and with the present interest in " the sea and all that therein is " the time may come when the boast of Pliny will be true.

CHARLES MINOR BLACKFORD, JR.